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Changes in soil microbial community, enzyme activities and organic matter fractions under long-term straw return in north-central China

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ABSTRACT

Field nutrients management practices influence soil biological properties and organic matter fractions. A long-term experiment (30-year) was conducted to investigate changes in soil microbial community, enzyme activities and organic carbon fractions under straw return in north-central China. Treatments included no-fertilizer control (CK) and maize straw return at rates of 0 (S0), 2250 (S1), 4500 (S2), and 9000 kg ha^{-1} (S3) under combined nitrogen and phosphorus fertilization. All fertilization treatments increased total phospholipid fatty acid (PLFA) and the abundances of Gram-negative (Gm^-) bacteria and fungi over the CK treatment. The S3 treatment increased total PLFA compared with the S0 treatment. The S2 and S3 treatments increased Gm^- bacterial abundance by 11.6 and 9.3%, respectively, and increased fungal abundance by 68.2 and 113.6%, respectively, compared with the S0. Fertilization increased the activities of β-glucosidase (BG), β-xylosidase (XYL), and N-acetyl-glucosaminidase (NAG) over the CK. The S2–S3 increased the activities of BG, XYL, and NAG by 10.5–20.7, 19.0–32.5, and 21.6–32.8% compared with the S0, respectively. Although the S1 and S3 had lower activities of phenol oxidase than the CK, the activities did not differ among the S0–S3 treatments. The S0–S3 treatments increased the concentration of total organic C (TOC) than the CK, and the S2–S3 increased TOC than the S0. There were no differences in soil light fraction (LF) and the light fraction organic C (LFOC) among the CK, S0, and S1. The LF and LFOC in the S2 increased by 14.7 and 33.9%, respectively, and these values in the S3 increased by 48.0 and 81.3%, respectively, relative to the S0. The S0–S3 treatments increased the heavy fraction organic C (HFOC) over the CK and the HFOC in the S2–S3 increased by 39.2–43.1% compared with the S0. The LFOC/TOC ratio was lower than the HFOC/TOC ratio for each treatment. Overall, low rates of straw return did not affect, while high rates of straw changed microbial community structure and increased the activities of most hydrolytic enzymes and the concentration of LFOC and HFOC under chemical fertilizer application.

1. Introduction

Soil organic matter (SOM) is the center of soil function and quality. High SOM can increase soil nutrients supply (Rochette et al., 1999), improve soil physical and biological properties (Gong et al., 2009; Guo et al., 2012), and enhance soil buffering capacity (Yang et al., 2012). Therefore, maintenance of SOM is particularly important for sustaining the productivity of agroecosystems. The enhancement of SOM increases soil carbon (C) sequestration (Lal, 2004). Many agricultural management practices such as fertilization, tillage, and straw return significantly influence SOM (Smith et al., 2005; Ludwig et al., 2011; Malhi et al., 2011). Total SOM is not sensitive to changes in soil management practices; however, one labile fraction, light fraction organic matter, which is dominated by newly incorporated plant-derived materials, and is central to nutrient cycling and microbial maintenance, responds rapidly to changes in soil management (Murata and Goh, 1997). Accordingly, this fraction is considered to be an early indicator of changes in soil quality (Haynes, 2000; Malhi et al., 2011). The SOM is most commonly estimated by soil organic carbon (SOC) content, and changes in SOC affect the C and nitrogen (N) cycle in terrestrial ecosystem (Malhi et al., 2011; Grandy et al., 2013). Changes in organic C and N of different organic matter fractions are the result of combined effects of soil chemical and biological properties.

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